I. LANGMUIR.

ELECTRON DISCHARGE APPARATUS.

APPLICATION FILED FEB. 20, 1918.

1,273,630. Patented July 23, 1918.

Fig. 1.

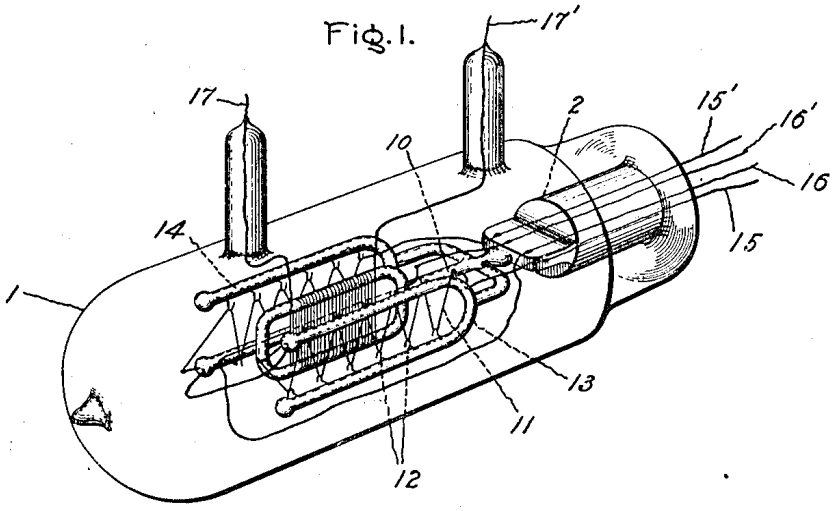


Fig. 3.

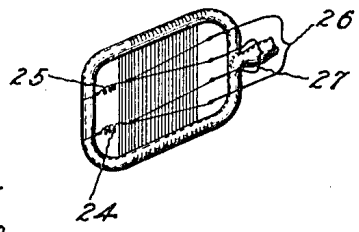


Fig. 2.

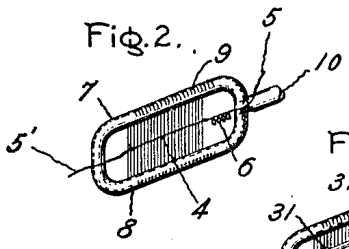


Fig. 4.

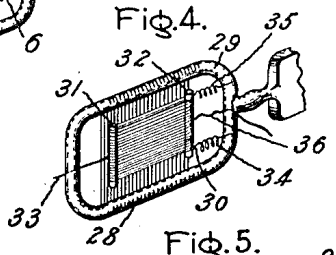
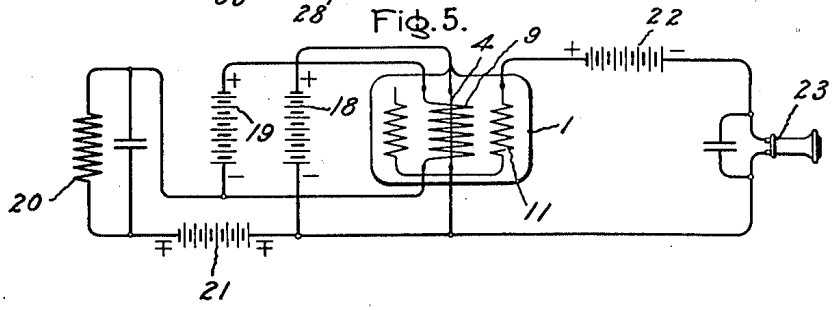


Fig. 5.



Inventor:
Irving Langmuir,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRON-DISCHARGE APPARATUS.

1,273,630. Specification of Letters Patent. Patented July 23, 1918.

Continuation in part of application Serial No. 795,609, filed October 16, 1913. This application filed February 20, 1918. Serial No. 218,200.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Electron-Discharge Apparatus, of which the following is a specification.

My present invention relates to electron discharge devices, for example, discharge tubes having an incandescent cathode. This application is a continuation in part of my prior application Serial No. 795,609, filed October 16, 1913, renewed March 14, 1916, as Serial No. 84,241.

Devices of this nature as described and broadly claimed in a copending application, Serial No. 795,610, filed October 16, 1913, are provided with an electron-emitting cathode, an anode, and a conducting body, commonly termed a "grid," consisting ordinarily of an electrical conductor located between cathode and anode for statically controlling the electrical discharge conditions of the tube. Electron discharge devices as described in the above application may be operated at exceedingly high voltages and have a high load capacity. This new apparatus is suited for use in a much wider field than former devices of this nature which were limited to low voltages and very feeble currents.

The present invention comprises various structural features of novelty which cooperate to improve the operating characteristics of devices of this type as well as to simplify their manufacture. For example, in accordance with my invention, the grid is made up of a considerable length of wire and is provided with terminals at each end which are sealed into the tube in order that current may be passed through the grid wire. The anode is also constructed in a similar way. This method of constructing a grid has a special advantage in that it enables the device to be operated in such a way that the potential gradient along the grid is the same as that along the filament.

In the accompanying drawings, various forms of apparatus are shown illustrative of my invention. Figure 1 illustrates an electron discharge tube with its parts assembled; Figs. 2 to 4, inclusive, show alternative forms of electrode and grid constructions, and Fig. 5 shows a system of connections which may be employed in order to produce a potential gradient along the grid which is the same as that along the filament.

As shown in Fig. 1, the various parts of the apparatus may be mounted in a tube or globe 1 upon a pedestal 2 similar to the mount employed for incandescent lamps. The cathode construction is shown in Fig. 2. It consists of a substantially straight filament 4 of highly refractory material, preferably tungsten, and provided with terminals 5, 5′. The filament 4 is mounted, preferably attached, to a light spring 6, between two oppositely disposed supports 7 and 8 constituting a frame-work, which is made of insulating material, such as glass or quartz. Upon this framework is wound a wire 9, the turns of which are closely adjacent to each other and are also very closely adjacent to but are out of contact with the incandescent cathode. The conductor 9, which may be very fine, constitutes a grid which, by means of applied potential, exerts a static control upon the electron discharge. The supporting framework for the cathode and the grid is attached to a rod 10, mounted upon the stem of the tube. Adjacent to the cathode and grid is the anode 11 which in the present case has been indicated as consisting of a wire strung in a zig-zag manner over hooks 12 upon fork-shaped supports 13 and 14, but it is not necessary that it should assume this particular form. Both anode and grid preferably consist of tungsten, but other gas-free refractory metals may be used. By constituting the anode a continuous conductor it can be conveniently heated by passage of current during evacuation of the device and for this purpose is attached to leading-in conductors 15, 15′. The cathode terminals 5, 5′ are supplied with current through leading-in wires 16, 16′. Although it is not necessary for all purposes to provide connections for each end of the grid it is desirable to do so when the potential applied to the grid is small and in the case of a straight or linear cathode the potential gradient along the grid may to advantage be the same as that on the filament. In this manner the potential drop from grid to cathode is the same along its length. The

grid is indicated in Fig. 1 as being attached to leading-in conductors 17, 17′ at opposite ends.

I have illustrated in Fig. 5 one system of connections which may be employed when the device which I have described is used as an amplifyer. In this case a battery 18 supplies the heating current for the cathode 4 and a battery 19 of the same voltage as battery 18 is applied to the terminals of the grid 9 so as to produce a potential gradient along the grid the same as that along the filament. The current or potential which is to be amplified may be applied to the coil 20 which is connected in a circuit between the grid and cathode. A battery 21 may also be connected in this circuit to impress upon the grid a normal potential at which the device will operate to the best advantage. With this arrangement it will be apparent that the difference of potential between any point on the cathode and the portion of the grid nearest thereto will be the same along the entire length of the cathode. A battery 22 connected in a circuit between cathode and anode furnishes current for the operation of a telephone receiver 23 or any other device desired for giving an indication of the amplified current.

In some cases it may be desirable to use a V-shaped conductor for the cathode and attach to its bight a spring as shown at 24, 25, in Fig. 3. In this manner contact of the conductor with the grid by sagging when the metal is expanded at high temperature is prevented. In Fig. 3 a plurality of loops are used in order to increase the amount of cathode surface. The filaments are connected in parallel by means of conductors 26, 27. In Fig. 4 not only the grid 28 is wound upon frame 29, but also the cathode wire 30 is wound upon stout metallic conductors 31, 32, consisting preferably of tungsten. The conductors 31 and 32 are attached respectively to an anchoring wire 33 and to two springs 34, 35, serving to hold taut the turns of the tungsten wire constituting the cathode, and to prevent them from coming into contact with the grid wire 28. The stranded copper conductor 36 may be used to conduct current to the cathode.

In preparing the apparatus, the preliminary exhaust is carried out by the most improved methods, such as used in incandescent lamp manufacture. The anodes are then subjected to an electron discharge or bombardment by impressing a suitable voltage between cathode and anode. When the anode consists of a conductor such as wire 11, Fig. 1, it is preferably heated by passage of current either before or during the bombardment. If desired the grid 4 may also be heated during the evacuation of the device. When the anode is plate shaped heating may form part of the treatment by electron bombardment, the discharge current being made heavy enough to heat the anode. The voltage should be so chosen at the beginning of the electron discharge treatment that blue glow is absent in the tube as this indicates that ionization of the residual gas by collision of gas molecules with electrons is taking place and under these conditions disintegration of the cathode is apt to take place. The discharge voltage is progressively increased, the gas being removed as fast as evolved, preferably by a Gaede molecular pump. This treatment is ordinarily continued until the discharge voltage is higher than the voltage at which the device is normally operated, but this rule will not hold true when the operating voltage is very high as substantially all the gas may be removed before the operating voltage is exceeded. Evacuation of the device should preferably be carried to a pressure as low as a few hundredths of a micron or even lower although no definite limits may be assigned. In any event, the evacuation should be so low that no appreciable gas ionization takes place during normal operation. When the cathode and anode are very close together and the discharge is confined to a direct path, a greater gas pressure is permissible than when the opposite is true.

An electron discharge tube may be used in various electrical systems, for example, as in receiving systems for radio telegraphy. The passage of electron current across the evacuated space between cathode and anode is controlled by the static potentials impressed upon the grid. A tube prepared as above described may be used to transmit currents limited in potential only by the dielectric strength of the glass, quartz or other material of the tube and the mechanical strength of parts subjected to static forces.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An electron discharge device comprising an evacuated receptacle containing a filamentary cathode adapted to be heated to incandescence, a coöperating anode, a grid made up of a plurality of turns of wire surrounding said cathode and terminals for both ends of said grid wire sealed into the wall of said receptacle, whereby current may be passed through the grid wire.

2. An electron discharge device comprising an evacuated receptacle containing a filamentary cathode adapted to be heated to incandescence, a coöperating anode, a grid made up of a plurality of turns of wire surrounding said cathode, and interposed between cathode and anode, terminals for both ends of said grid wire sealed into the walls of said receptacle, and means for heating said anode independently of the current passing between cathode and anode.

3. An electron discharge device comprising an evacuated receptacle containing a filamentary cathode, means for passing a current through said cathode for heating it to incandescence, a grid made up of a plurality of turns of wire surrounding said cathode and means for producing a difference of potential between the ends of said grid wire corresponding to the difference of potential between the terminals of the cathode.

4. An electron discharge device comprising an evacuated receptacle containing a cathode adapted to be heated to incandescence, a coöperating anode, and a discharge controlling grid and means whereby the same difference of potential may be produced between cathode and grid at all points along the length of the cathode.

5. An electron discharge device comprising an evacuated receptacle containing a cathode in the form of a substantially straight filament which is adapted to be heated to incandescence, a grid consisting of a plurality of turns of wire surrounding said filament and terminals for both ends of said grid wire sealed into the wall of said receptacle.

6. Means for amplifying electric currents comprising an electron discharge device having a filamentary cathode, a coöperating anode and a grid consisting of a plurality of turns of wire surrounding said cathode, a source of current for heating said cathode, a second source of current of the same potential as the first source for producing a potential gradient along the grid the same as that along the cathode, and means for supplying the current to be amplified to a circuit connecting the grid and cathode.

7. Means for amplifying electric currents comprising an electron discharge device having a filamentary cathode, a coöperating anode and a grid consisting of a plurality of turns of wire surrounding said cathode, a source of current for heating said cathode, means for impressing a potential difference between the ends of said grid equal to that between the ends of the cathode, and means for impressing a variable potential between the grid and cathode.

8. Means for amplifying electric currents comprising an electron discharge device having a cathode adapted to be heated to incandescence, a coöperating anode and a discharge controlling grid inclosed in an evacuated receptacle, said cathode and grid being so constructed and arranged that when the cathode is heated to incandescence the same difference of potential may be impressed between all points on the cathode and the points on the grid nearest thereto.

In witness whereof, I have hereunto set my hand this 16th day of February, 1918.

IRVING LANGMUIR.